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A Test of Case Linkage Principles with South African Serial Sex Offences.

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Abstract

Case linkage involves identifying crime series on the basis of behavioral similarity and distinctiveness. Research regarding the behavioral consistency of serial rapists has accumulated; however, it has its limitations. One of these limitations is that convicted or solved crime series are exclusively sampled whereas, in practice, case linkage is applied to unsolved crimes. Further, concerns have been raised that previous studies might have reported inflated estimates of case linkage effectiveness due to sampling series that were first identified based on similar modus operandi (MO), thereby overestimating the degree of consistency and distinctiveness that would exist in naturalistic settings. We present the first study to overcome these limitations; we tested the assumptions of case linkage with a sample containing 1) offenses that remain unsolved, and 2) crime series that were first identified as possible series through DNA matches, rather than similar MO. Twenty-two series consisting of 119 rapes from South Africa were used to create a dataset of 7021 crime pairs. Comparisons of crime pairs that were linked using MO vs. DNA revealed significant, but small differences in behavioral similarity with MO-linked crimes being characterized by greater similarity. When combining these two types of crimes together, linked pairs (those committed by the same serial offender) were significantly more similar in MO behavior than unlinked pairs (those committed by two different offenders) and could be differentiated from them. These findings support the underlying assumptions of case linkage. Additional factors thought to impact on linkage accuracy were also investigated.

Keywords: comparative case analysis, linkage analysis, behavioral linking, sexual assault, sexual offense

1. INTRODUCTION

Case linkage is practiced by police agencies internationally and involves linking crimes together to form a series on the basis of behavioral similarity and distinctiveness (and in some cases, temporal or geographical proximity). It is sometimes referred to as comparative case analysis or linkage analysis. Whilst case linkage can be applied to a range of crime types, historically it has been used more often with serious offenses, such as murder and stranger rape. Police units exist in different countries who conduct case linkage on these more serious forms of crime, for example, the Serious Crime Analysis Section in the United Kingdom and the Investigative Psychology Unit of the South African Police Service. Case linkage can assist the Police in several ways including the efficient deployment of limited police resources, increasing the amount of evidence against an offender by combining that from different crime scenes and different witnesses, and, after arrest, using evidence of behavioral similarity as similar fact evidence in the prosecution of an offender (Labuschagne, 2010; Woodhams, Hollin *et al.*, 2007).

Case linkage can take a proactive form whereby databases of unsolved crimes are searched to identify pairs (or groups) of crimes that share behavioral similarities, and which might be temporally or geographically proximal. However, it is more common for it to be conducted in a reactive manner, where the case linkage practitioner is presented with one offense (often termed the index offense) and asked to identify other crimes that were likely committed by the same offender (Woodhams, Bull *et al.*, 2007). Such scenarios might arise because of the severity of the index offense or because a suspect has been identified for the index offense and the investigating officer wishes to identify any other offenses that the suspect may have committed.

To be able to link crimes together on the basis of behavior requires two assumptions about the behavior of serial offenders to be met. The first assumption, the Offender Consistency Hypothesis (Canter, 1995), requires offenders to display a degree of consistency in the way they commit their crimes across a series. The second assumption is that offenders must show a degree of distinctiveness in the way they commit their offenses so that their offenses can be differentiated from those of other offenders (Bennell & Canter, 2002). These assumptions have been the subject of recent empirical investigations with a range of crime types, including: burglary (Bennell & Canter, 2002; Bennell & Jones, 2005; Goodwill & Alison, 2006; Green *et al.*, 1976; Markson *et al.*, 2010; Yokota & Canter, 2004), robbery (Woodhams & Toye, 2007), sex offenses (Bennell *et al.*, 2009; Canter *et al.*, 1991; Grubin *et al.*, 2001; Knight *et al.*, 1998; Lundrigan *et al.*, 2010; Santtila *et al.*, 2005; Woodhams, Grant *et al.*, 2007; Yokota *et al.*, 2007), homicide (Bateman & Salfati, 2007; Harbort & Mokros, 2001; Salfati & Bateman, 2005; Santtila *et al.*, 2008; Sorochinski & Salfati, 2010), arson (Santtila *et al.*, 2004) and car-theft (Tonkin *et al.*, 2008).

1.1. Consistency and variability in sexual offending behavior

With regards to the first assumption of case linkage, behavioral consistency, it has been suggested that sexual fantasy is one reason why we might observe consistency in the offending behavior of serial rapists. This might be in a more general sense or because of the presence of a paraphilia. Paraphilias are "repeated and intense sexual urges, behaviour or fantasies in response to objects or situations that society deems inappropriate" (Bennett, 2006, p. 262). They have been found to co-occur with sexual aggression (Abel & Rouleau, 1990; Bradford *et al.*, 1992, both as cited in Lussier *et al.*, 2007). Based on a large scale study of apprehended sex offenders, Gee and Belofastov

(2007) report that for the majority of sex offenders their offending behavior is fantasy-driven.

Fantasy can influence a range of crime scene behaviors including victim selection, the location of the offense, the method of approach, the methods used to control the victim, sexual behaviors and the behaviors needed to complete the offense without being apprehended (Gee & Belofastov, 2007). Paraphilias can affect the "relationship" rapists have with their victim during the offense (Hazelwood & Warren, 2000). Such relationships include "master-slave" for sadistic offenders, and "boyfriend-girlfriend" for an offender with a fantasy of a consenting sexual relationship. Hazelwood and Warren (2000) explain that the behaviors used to control the victim will be very relevant to the offender's fantasy. If the offender has a fantasy of a consenting relationship, they argue, he will not want to resort to physical violence to control the victim, whereas physical violence will be important to the sadistic offender.

Based on their research, Gee and Belofastov (2007) propose that an offender's core sexual fantasy remains static over time but that the complexity of the fantasy can develop, "hence, a sexual offender is more likely to deploy similar strategies and resources across offences, in keeping with the origin of their core fantasy structure" (p. 64). As a sexual fantasy becomes more complex, completion of the sexual offense can become more difficult (Gee & Belofastov, 2007). It can necessitate greater control of the victim, which might be achieved through increased physical aggression (Hazelwood & Warren, 2000). For example, with adolescent child abusers, Leclerc and Tremblay (2007) found use of violence to be associated with the increasing intrusiveness of the sexual behavior desired by the adolescent. These research findings suggest that both stability and evolution will be evident within a rape series, and that rapists will vary in

the degree to which their offending behavior is driven by fantasy. Variation in behavioral consistency between offenders as well as a degree of consistency across an individual's series should therefore be expected. It follows that case linkage will not be an exact science.

1.2. Previous linkage research on serial sex offenders

Using a range of methods, eight studies have investigated the consistency and/or distinctiveness of behavior exhibited by serial sex offenders across their series. Some studies have quantified behavioral consistency in terms of how frequently offenders exhibit the same behaviors (or clusters of behaviors) across crimes from their own series (Grubin *et al.*, 2001; Lundrigan *et al.*, 2010). The observed co-occurrences are compared to what would be expected by chance alone. Both Grubin *et al.* (2001) and Lundrigan *et al.* (2010) found these frequencies to be significantly greater than chance. Lundrigan *et al.* (2010) also demonstrated that the consistency in environmental behaviors (characteristics of the crime sites selected) displayed within series was significantly greater than that displayed across different series. In Grubin *et al.*'s (2001) study, each offense in the dataset was compared to all others, in terms of MO, resulting in a ranked list of offenses. Those offenses at the top of the ranked list were most similar in behavior to the crime in question. Having conducted this procedure for all crimes in the dataset, Grubin *et al.* were able to assess whether the crimes ranked within the top 10% more often than chance represented offenses from the same series. They found this occurred significantly more often than would be expected by chance alone.

Similarly, Yokota *et al.* (2007) were able to assign sex offenses to the correct offender on the basis of similar MO at rates greater than what would be expected by chance. Eighty-one serial sex offenders were selected from a database of 868 offenders

and one offense was chosen from the series of each of these offenders. Eighty-one trials took place whereby each of the 81 offenses was compared to all others in the database in terms of similarity in MO behavior. The 868 offenders within the database were rank ordered depending on the similarity of their MO to the offense in question. Thirty per cent of the time the correct offender was ranked number one out of 868. The rank at which the correct offender was placed by the system ranged from 1-339.

Knight *et al.* (1998) assessed the consistency of offense behaviors across the five most recent crimes of a sample of serial sex offenders. Offense behaviors were arranged into domains and the within-series consistency assessed for the domains, as well as the individual behaviors composing the domains, using a rating scale. Having a firearm present, cutting/slashing clothing, an excessive response to victim resistance, and the victim being bound were rated as high or very high in consistency. The offender behaviors moderate in consistency were alcohol consumption during the crime, taking drugs during the crime, the intentional infliction of pain, excessive profanity, sexual dysfunction, sexual comments, the offender showing interest in the victim's enjoyment (e.g., pseudo-intimacy), being inquisitive, the offender being aroused by causing harm, the offender humiliating the victim, sadistic infliction of pain, and the sexual use of a foreign object during the incident. How well these variables differentiated serial offenders was not, however, assessed.

Other researchers (Bennell *et al.*, 2009; Canter *et al.*, 1991; Mokros & Alison, 2002; Santtila *et al.*, 2005; Woodhams, Grant *et al.*, 2007) have used Jaccard's coefficient to measure similarity in MO behavior between pairs of sexual crimes. Jaccard's coefficient ranges from 0-1 and when used in this context larger values represent greater similarity in MO behavior. The Jaccard's coefficients obtained for

linked crime pairs (created by pairing two crimes committed by the same serial offender) can be contrasted with the values obtained for unlinked crime pairs (typically created by pairing two crimes committed by two different serial offenders). The intention behind such analyses is to demonstrate that intra-individual variation in behavior is less than inter-individual variation (Bennell & Canter, 2002). Linked crime pairs should therefore be characterized by larger Jaccard's coefficients than unlinked crime pairs.

With a sample of 28 convicted adult serial sex offenders, Mokros and Alison (2002) reported an average Jaccard's coefficient of .41 for linked crime pairs compared to .27 for unlinked crime pairs. Identical figures were reported by Bennell *et al*. (2009) with a sample of 41 convicted adult serial rapists. With a small sample of seven serial juvenile sex offenders, who had admitted their offenses and for which there was corroborating evidence, Woodhams, Grant *et al.* (2007) reported average Jaccard's coefficients of .39 for linked pairs and .17 for unlinked pairs.

Some researchers have gone further than this and have tested whether behavioral similarity (as measured using Jaccard's coefficient) can be used to 1) accurately differentiate linked from unlinked crime pairs, or 2) accurately assign crimes to the correct series. With a sample of four solved rape series (constituting 12 offenses), Canter *et al.* (1991) investigated how accurately crime pairs could be classified as linked or unlinked. Using a coefficient of $\geq .3$ as a cut-off, 85% of the 66 crime pairs were classified correctly.

Using Jaccard's coefficient as a measure of behavioral similarity, Santtila *et al.* (2005) used multidimensional scaling to plot 43 offenses in a two-dimensional space whereby offenses closer to one another in space were more behaviorally similar. For

each offense, its five closest neighbors were extracted and examined for series membership. Another case from the same series was present within these five offenses 40% of the time. If the ten closest offenses were analyzed this figure rose to 60%.

1.3. Limitations of previous linkage research

Whilst these results are all promising in terms of supporting the underlying assumptions of case linkage for serial sex offenses, they are characterized by a number of limitations. One limitation is that the findings can be affected by the placement of the decision threshold, or cut-off (Bennell *et al.,* 2009). As Bennell and colleagues explain, often studies have set specific decision thresholds when assessing linkages in terms of choosing a specific cut-off for deciding when a crime pair should be considered linked (Canter *et al.,* 1991), or stipulating the number or percentage of ranked crimes to be assessed for the presence of crimes from the same series (Grubin *et al.,* 2001; Santtila *et al.,* 2005). Bennell *et al*. argue "Consequently, results that emerge from the use of only one threshold are likely to provide an extremely distorted picture of one's ability to link crimes" (p. 298). To overcome this limitation, Bennell *et al.* propose ROC analysis as the preferred form of analysis for case linkage research because it can assess the probability of making correct and incorrect linkage decisions across the full range of decision thresholds.

Linking crimes behaviorally can result in four different outcomes, two of which are correct (hit, correct rejection) and two of which are incorrect (false alarm, miss)[i] (Bennell, 2005). ROC analysis plots the probability of a hit versus the probability of a false alarm at each decision threshold (e.g., from 0 to 1 if using Jaccard's coefficient) rather than just one. From these values a curve is plotted (the ROC curve) with the values for strict cut-offs (large Jaccard's coefficients) located in the bottom left corner

of the plot and the values for lenient cut-offs in the top right corner of the plot. Typically the curve would be a concave shape. If crimes that are linked can be differentiated accurately from crimes that are not linked this would result in a high overall level of discrimination accuracy and therefore a high ROC curve. Overall discrimination accuracy is quantified in ROC analysis from the statistic called the Area Under the Curve (AUC). A high ROC curve would correspond with a large AUC. Interested readers are referred to Bennell (2005) and Bennell *et al.* (2009) for a more in-depth discussion of the advantages of ROC analysis for the evaluation of case linkage principles.

To demonstrate the utility of ROC analysis, Bennell *et al.* (2009) assessed how accurately linked and unlinked serial rape pairs could be differentiated when using a wide range of decision thresholds. If the assumptions of behavioral consistency and distinctiveness are valid it should be possible to differentiate linked from unlinked crime pairs with a good degree of accuracy. Bennell *et al.*'s analysis produced an AUC of .75, which can be considered good according to published standards (Swets, 1988).

A second limitation of the existing research on case linkage relates to the types of offenses that have been sampled. Studies of the case linkage principles, by their nature, require researchers to be confident of the membership of offenses to a given series. In the past, this has been achieved by sampling offenses which have been linked together, and to a common offender, on the basis of a conviction. The difficulty with this is that these offenses might have originally been linked together, solved and prosecuted due to the offender's behavioral consistency and distinctiveness. This means they might be characterized by greater behavioral similarity than would be the

case in reality (i.e., in naturalistic police settings) where case linkage is attempted on unsolved crimes (Bennell & Canter, 2002).

Researchers have therefore suggested that a way forward would be to sample unsolved offenses that have been linked by DNA (Sorochinski & Salfati, 2010; Woodhams, Bull *et al.*, 2007). However, unsolved crimes that have been linked by DNA still might have first been identified as a possible series due to similar MO. To illustrate this point, in South Africa an investigating officer might identify a potential rape series on the basis of similar MO and request that the samples taken from the victims' Sexual Assault Evidence Collection Kits be processed for DNA and compared to each other as a priority. In this scenario, the crimes might remain unsolved and be linked by DNA but the limitation of research conducted on such a sample would remain; that the offenses were initially identified as a series due to behavioral consistency and distinctiveness. Therefore, what is instead needed is a sample of series where it is possible to confirm that they were first linked by DNA, not by MO.

A third limitation relates to how offenses are sampled from series in studies of case linkage. It has been suggested in the existing case linkage literature that to include series of different lengths within an analysis risks biasing results by giving greater weight to the consistency (or inconsistency) of prolific offenders (Bennell & Canter, 2002). Researchers have therefore controlled for the representation of prolific offenders in datasets by limiting the number of crimes selected from each series (e.g., Bennell *et al.*, 2009; Santtila *et al.*, 2005). Typically, this decision is based on the size of the smallest series in the dataset. This does not, however, reflect the reality of the linking task in practice where databases of offenses that are searched will contain series of different lengths. To the authors' knowledge, a test of the effect of this sampling

strategy has not been conducted previously and therefore the impact of this sampling method has yet to be established.

A final limitation is that research conducted thus far on linking serial sex offenses has largely been limited to samples of series from the UK (Bennell *et al.,* 2009; Canter *et al.,* 1991; Grubin *et al.,* 2001; Mokros & Alison, 2002; Woodhams, Grant *et al*., 2007) and other European countries (Santtila *et al.*, 2005). The exceptions are samples from Canada (Grubin *et al.,* 2001), Japan (Yokota *et al.,* 2007), the United States (Knight *et al.,* 1998) and New Zealand (Lundrigan *et al.,* 2010). This is problematic because cultural differences in the expression of crime scene behaviors could impact the effectiveness of case linkage by affecting the second assumption of case linkage; distinctiveness. For example, in one country, the use of a firearm in a sexual assault might be relatively uncommon because of restrictions on firearm ownership and the limited availability of illegal firearms. In contrast, in another country the situation could be quite different. As an illustration, the number of rapes in which weapons are used/displayed in South Africa is much higher (50%, Jewkes & Abrahams, 2002; 40%, Vetten & Haffejee, 2005) than in England and Wales (1-2%, Home Office, 2009). It is therefore important to determine whether evidence of good predictive accuracy for linked versus unlinked crimes found with European data generalises to other countries. This is particularly important in the case of South Africa where linkage analysis does not just inform investigative decision-making but is admitted in legal proceedings in support of similar fact evidence (Labuschagne, 2006, 2010).

1.4. Research regarding factors that affect consistency

As well as investigating the degree of behavioral consistency and distinctiveness shown by serial sex offenders and whether this is sufficient for their offenses to be

linked, research has been conducted with a range of crime types to determine if there are factors that can affect the behavioral consistency displayed by serial offenders. This research has been informed by theories from personality psychology which propose that factors such as expertise and time-elapsed between events affect the degree of consistency observed in non-criminal human behavior (see Woodhams, Hollin *et al.*, 2007 for a review).With non-criminal behavior, experience of an activity is related to greater behavioral consistency (Hettema & Van Bakel, 1997) and it is proposed that this is because the more frequently a behavioral strategy is triggered in response to a situation the more likely it will be activated again in the future (Greene, 1989). For non-criminal behavior greater consistency is also observed across events that are closer together in time (Pervin, 2002). This is because over a shorter time period a person's personality system, which is purported to consist of mental representations that when activated result in behavior (Mischel, 1999), will have had little time to develop or change. Woodhams, Hollin *et al.* (2007) suggested that we might therefore see greater behavioral similarity between linked crime pairs that are temporally proximal compared to pairs that are temporally distal, and we might expect to see an increase in behavioral consistency as serial offenders gain expertise in their offending behavior.

Three studies have now directly assessed whether there is a relationship between the time elapsed between linked crime pairs and behavioral similarity. These have been conducted with serial burglaries (Markson *et al.*, 2010), car-thefts (Tonkin *et al.*, 2008), and juvenile stranger sex offenses (Woodhams *et al.*, 2008). No evidence for such a relationship has been found.

Tonkin *et al.* (2008) assessed the effect of expertise on behavioral consistency by comparing the Jaccard's coefficient for the first and last pair in the series committed

by their 20 most prolific car thieves. If expertise increased behavioral consistency, the last pair in the series would be expected to be characterized by greater similarity than the first pair in the series. No significant difference was found.

1.5. The Current Study

The current study aimed to extend the existing research on case linkage, and address various limitations, by:

1. Testing the assumptions of case linkage using ROC analysis, with a South African sample of serial rapes, predicting that;
    a) Linked crime pairs would be characterized by greater behavioral similarity (larger Jaccard's coefficients) than unlinked crime pairs.
    b) Linked crime pairs could be accurately distinguished from unlinked crime pairs on the basis of similarity in MO behavior.
2. Including in the sample rape series that remain unsolved rather than relying solely on samples of solved or convicted rape series.
3. Determining, where possible, the basis on which each series in the sample was first identified as a potential series, allowing for a comparison of the behavioral similarity of crime pairs from series first identified by DNA compared to those first identified from MO. It was tentatively predicted that;
    a) Pairs of crimes from DNA-identified series would be characterised by less behavioral similarity than those from MO-identified series.
4. Conducting an explicit test of the effect of sampling all offenses from a series versus a constant number of offenses from a series.
5. Investigating the effect on behavioral similarity of time elapsed between offenses from the same series. It was predicted that;

a) There would be a negative relationship between time elapsed in days between a pair of offenses and their level of behavioral similarity.

6. Investigating the effect on behavioral similarity of a serial rapists' experience in terms of the known rapes he has committed. It was predicted that;
    a) Pairs of crimes occurring later in a series would be characterised by greater behavioral similarity.

2. METHOD

2.1. Data

One hundred and nineteen cases of serial sexual assault were identified by the Investigative Psychology Unit (IPU) of the South African Police Service, for which a police file existed, which contained, as a minimum, a copy of the victim's account of the sexual assault. Where the victim's account was in Afrikaans, it was translated into English by the second author who is fluent in both languages. The vast majority of the offenses were defined as a rape (97%, n = 115), according to the Criminal Law (Sexual Offenses and Related Matters) Amendment Act (2007), with three cases being classified as attempted rapes and one being an indecent assault. These cases were committed by 22 male serial rapists. A serial offender was defined as an offender who had offended against two or more victims on different occasions[ii]. An offender who on one occasion had assaulted two or more victims at the same time was not considered to be a serial offender.

The number of crimes in a series ranged from two to 65 with the mode being three. For 74% (n = 88) of the cases, an offender had been convicted, 14% of the offenses (n = 17) were solved and the remaining 11% (n = 14) were unsolved. For nine series, the files confirmed that they were first linked by DNA. For a further nine series,

they had initially been linked due to similar MO. For two series, how they were first linked had not been recorded. For the remaining two series some of the offenses were linked by DNA first and the others by similar MO, however it was not clear which offenses were first linked by DNA and which by MO. Of the 119 victims, 93% (*n* = 111) were female and 25% (*n* = 25) were aged less than 18 years. Ninety-two per cent of victims (*n* = 109) were strangers to the offender.

2.2. Procedure

Prior to reading the police files, published checklists of rapist behavior (Bennell *et al.*, 2009, 2010; Canter & Heritage, 1990; Canter *et al.*, 2003; Mokros & Alison, 2002; Porter & Alison, 2004; Salfati & Taylor, 2007; Santtila *et al.*, 2005; Woodhams, 2008) and a checklist which had been developed previously on a sample of South African rapes (De Wet, 2008) were consulted. These different checklists were amalgamated to form an overall checklist of rapist crime scene behaviors (see Appendix 1). Using the contents of the police file, the first author coded each crime in the dataset against the checklist in a binary fashion with a 1 being recorded where a behavior reportedly occurred and a 0 being recorded where it did not (or where this was unknown). For two offenses from two different series the offender had assaulted more than one victim during the same event. In these cases one victim was chosen at random from the offense and only the behaviors in which the offender engaged with this victim were coded. The inter-rater reliability of this coding was assessed with 10% of the sample, which was chosen at random and dual coded. The kappa statistic was 0.70 which indicates a 'good' and 'substantial' level of reliability (Cicchetti, 1994; Landis & Koch, 1997), and the percentage agreement was 91.47%. How a crime series was first identified was extracted from the police file where this had been recorded.

Once each offense had been coded for the offender's crime scene behavior, pairs of crimes were created. A method commonly adopted for assessing the assumptions of case linkage (Bennell & Canter, 2002; Bennell & Jones, 2005; Bennell *et al.,* 2009; Markson *et al.,* 2010; Tonkin *et al.,* 2008; Woodhams & Toye, 2007) was used in this study. This method was originally proposed by Bennell (2002). This involves creating a subset of linked crime pairs and a subset of unlinked crime pairs and generating a measure of behavioral similarity for each pair (quantified using Jaccard's coefficient). This was conducted using a program called B-Link which was devised by Dr. Craig Bennell in 1999.

To assess whether the inclusion of all offenses from each series in the analysis would affect the results, in terms of not controlling for the behavior of prolific offenders, two different sets of crime pairings were needed. Initially, a dataset of pairs were created using all offenses from all series and generating all possible pairs. This resulted in 599 linked crime pairs and 6422 unlinked crime pairs (N = 7021). To create the alternative dataset, two offenses were randomly selected from each of the 22 series. Two offenses were selected since this was the smallest length of a series. All possible pairings were generated resulting in a new dataset of 22 linked crime pairs and 924 unlinked crime pairs (N = 946).

The binary coding of the offender's behavior for each offense were the input data for calculating Jaccard's coefficients between pairs of crimes. As noted above, Jaccard's coefficient is often used in linkage research as a measure of behavioral similarity. This is because it has the advantage of discounting joint non-occurrences of a behavior in the calculation of similarity. As explained by Bennell and Canter (2002), this is advantageous due to the quality of information within police files, which was not

collected for the purposes of research. Whilst an offender might have displayed a behavior during an offense its eventual recording in the police file can depend on a number of factors (and thus, non-occurrences of behavior in the dataset may not actually indicate that a behavior did not occur). These include the victim's memory, their willingness or ability to report the details of the offense, the interviewer's skill and, in the case of a victim statement, how closely what is written in the statement reflects what the victim reported in interview (Alison *et al.*, 2001). As noted by Bennell and Jones (2005), such errors will add noise to the data reducing the likelihood of finding relationships rather than increasing this possibility.

Having calculated the similarity in MO behavior for each crime pair (quantified by one Jaccard's coefficient for each pair), various analytical steps were taken. Tests of differences were calculated to compare the behavioral similarity of different types of linked crime pairs (DNA linked vs. MO linked), as well as the linked and the unlinked crime pairs. Following these tests, a standard logistic regression analysis was conducted to examine the extent to which the measures of behavioral similarity could be used to accurately discriminate between linked and unlinked crime pairs.

When conducting logistic regression analysis it is important to validate the results to ensure that they generalise beyond the data used to develop the regression model (Tabachnick & Fidell, 1996, as cited in Santtila *et al.*, 2005). To carry out the cross validation, we used the leave-one-out method from the syntax reported in Herrmann (1998). Leave-one-out cross-validation involves taking each case out of the dataset one at a time. When a given case has been extracted, a logistic regression model is developed using the remaining dataset (representing the development data), which is then applied to the extracted case only (representing the validation data) to produce a

predicted probability. This case is then returned to the dataset and the procedure repeated with the next case in the dataset until cases have been exhausted. The predicted probabilities produced from the syntax formed the input data for the ROC analysis. All analyses were conducted with PASW 18.

3. RESULTS

3.1. Pairs identified from DNA matches versus similar MO

Prior to assessing the two underlying assumptions of case linkage, the subset of linked crime pairs, which was composed of series first identified by DNA or series first identified on the basis of similar MO, was assessed to determine if these two types of linked pairs differed in behavioral similarity. Eighteen series were compared, nine which had been first linked by DNA and nine which had been first linked on the basis of similar MO. A Kolmogorov-Smirnov test had confirmed that the distribution of Jaccard's coefficients was not significantly different from a normal distribution therefore an independent-samples t-test was conducted.

The crime pairs from the series which had been identified from MO had larger Jaccard's coefficients (M = .51, SD = .11) compared to the pairs constituting series that had been linked first by DNA (M = .47, SD = .10). However, this difference was only just significant ($t_{(171)}$ = 1.98, p = .049, d = .38) and represented a small effect size (Cohen, 1988). For this reason, in subsequent analyses the linked crime pairs were analyzed together rather than being split into sub-types.

3.2. Analyses using all crimes in the series

The distribution of Jaccard's coefficients for the linked and the unlinked crime pairs were plotted on a histogram to examine the degree of overlap for the two distributions (see Fig. 1). While the two distributions overlap, the linked crime pairs

tend to have larger Jaccard's coefficients (M = .52, SD = .10, Range = .20 - .85) in general than the unlinked crime pairs (M = .34, SD = .10, Range = .01 - .73), representing greater similarity in MO behavior.

Insert Fig. 1 approx here

The distributions of the linked and the unlinked crime pairs did not depart significantly from a normal distribution. Thus, a paired t-test was conducted to determine if the difference between linked and unlinked crime pairs was significant. This requires an equal number of pairs in each subset, therefore 599 unlinked crime pairs were chosen randomly from the larger set of 6422 unlinked crime pairs. The linked crime pairs were significantly more similar in MO than the unlinked crime pairs ($t_{(598)}$ = 29.95, p < .001, d = 1.80), with a very large effect size (Cohen, 1988).

ROC analysis was conducted to assess the predictive accuracy of similarity in MO behavior using the predicted probabilities produced by the leave-one-out logistic regression analysis. The resulting AUC was .88 (SE = .01, 95% CI = .86-.89), representing a significant (p<.001) and excellent level of predictive accuracy (Hosmer & Lemeshow, 2000). The ROC curve can be seen in Fig. 2.

Insert Fig. 2 approx here

Youden's index was calculated to identify the decision-threshold (for deciding when a pair should be considered linked) at which the proportion of hits would be maximised whilst the proportion of false alarms would be minimised (Bennell, 2005). This threshold corresponded with a Jaccard's coefficient of .425.

3.3. Analyses using two crimes per series

The same analyses as reported in the previous subsection were repeated with the smaller subset of crimes where just two offenses per serial offender had been sampled.

The distributions for behavioral similarity can be seen in Fig. 3. As was the case when all crimes per series were sampled, the linked crime pairs continued to be characterized by greater behavioral similarity and larger Jaccard's coefficients in general (M = .47, SD = .12, Range = .23 - .74) than the unlinked crime pairs (M = .34, SD = .11, Range = .10 - .71). The linked crime pairs in this subsample were, however, characterized by less behavioral similarity than the linked pairs in the previous analysis, as can be seen from the mean Jaccard's coefficient, which decreased from .52 to .47. Overall, the linked crime pairs appeared to be characterized by greater similarity in MO behavior than the unlinked crime pairs.

Insert Fig. 3 approx here

The distributions of the linked and the unlinked crime pairs in this sub-sample were not significantly different from a normal distribution, therefore a paired t-test was conducted using 22 randomly selected unlinked crime pairs from the subset of 924 unlinked crime pairs. This test confirmed that the linked crime pairs were significantly more similar in MO behavior than the unlinked crime pairs ($t_{(21)} = 4.96$, $p < .001$, $d = 1.43$), with a large effect size (Cohen, 1988). The effect size was, however, smaller in magnitude than in the previous analysis.

A leave-one-out cross-validation analysis was again conducted and an AUC computed using the predicted probabilities for the 946 pairs (22 linked crime pairs and 924 unlinked crime pairs). The ROC curve can be seen in Fig. 4. The AUC was .77 (p<.001, SE = .05, 95% CI = .67-.87) which is smaller than that from the previous analysis, suggesting a reduction in predictive accuracy when the influence of prolific offenders is controlled for. However, this AUC still represents a significant and adequate level of predictive accuracy (Hosmer & Lemeshow, 2000).

Insert Fig. 4 approx here

Youden's index was again calculated to identify the decision-threshold at which the proportion of hits would be maximised whilst the proportion of false alarms would be minimised (Bennell, 2005). This threshold represented a Jaccard's coefficient of 0.35.

3.4. The effect of time elapsed on behavioral consistency

The number of days elapsed between the dates of offenses constituting each linked pair (n = 599) was calculated. This was correlated with the behavioral similarity of each pair using a Spearman's correlation analysis (due to the skewed distribution of the time elapsed variable). For those series consisting of five or more offenses, individual correlations were also conducted to assess whether, for each offender, there was a relationship between time elapsed and behavioral similarity. The results of all of these analyses can be seen in Table 1. They suggest little support for a relationship between behavioral consistency and time elapsed between offense pairs.

Insert Table 1 approx here

3.5. The effect of experience on behavioral consistency

To investigate the effect of experience on behavioral consistency, those series containing five or more offenses were selected (n = 9) and from these the first known offense pair and the last known offense pair were extracted. The similarity in MO for the first and last pair in each series can be seen in Table 2. An increase in similarity in MO from first pair to last pair can be seen in seven of the nine series, indicating greater behavioral consistency for offenses later in the series, although for some the increase in Jaccard's coefficient is small.

Insert Table 2 approx here

4. DISCUSSION

4.1. Assessments of methodological variation

The data collected for the purpose of this research study provided an opportunity to test a number of methodological issues, as well as the fundamental principles of case linkage. In the past, valid concerns have been raised regarding whether findings generated from convicted samples of serial offenders would generalize to unsolved series. Specifically, concerns were raised as to whether the levels of behavioral consistency and distinctiveness found with convicted crime series would generalize to unsolved crime series or if these would be characterized by lower levels of consistency and distinctiveness (Bennell & Canter, 2002). This study took a first step in investigating this concern by comparing the behavioral similarity of linked crime pairs which were first identified as part of a series based on MO to those identified from DNA matches. The crime pairs taken from series first identified by MO were more behaviorally similar than those that were first identified on the basis of DNA evidence, however, this difference was only just significant with a small effect size. Having said this, before concerns about the ability to generalize from convicted crime series to unsolved crime series can be completely allayed these findings would need to be replicated and larger samples of first-linked-by-MO and first-linked-by-DNA series collected to allow for comparative ROC analysis.

We were also able to assess the effect of controlling for the behavioral expression of prolific serial offenders in the analyses by varying whether we sampled all crimes in each series or randomly chose a constant number of crimes from each series. These two methods represent those that have been used in existing studies. When sampling all offenses from each series, our analysis yielded an AUC of .88 whereas this

decreased to .77 when sampling a constant number of offenses from each series. Similarly, the decision-threshold for predicting that a pair of crimes is linked, as calculated using Youden's index (Bennell, 2005), varied when using these different sampling methods. When sampling all offenses from all series, the threshold represented a larger Jaccard's coefficient than when sampling a constant number of offenses from each series. This variation suggests that findings from published studies which have utilized different methods for sampling crime pairs from series might not be comparable. In reality the number of offenses from crimes series would not be constant in databases of offenses used by the police for case linkage and thus adopting the more stringent test in case linkage research (whereby a constant number of offenses per series is sampled) does not necessarily reflect the reality of the linking task. Indeed, studies that sample a constant number of offenses from each series could be underestimating the accuracy with which crimes can be behaviorally linked in reality. In future studies, researchers could therefore present both sets of output, where sample sizes allow.

4.2. Behavioral consistency and distinctiveness in serial rape

Tests of difference demonstrated that the linked crime pairs in our sample were significantly more similar in MO behavior than the unlinked crime pairs with large effect sizes. The Jaccard's coefficients obtained for our linked and unlinked crime pairs in all analyses were larger than those found in existing studies of adult serial rapists (Bennell *et al.*, 2009; Mokros & Alison, 2002), but not very different. As has been the case with existing studies (Bennell *et al.*, 2009; Mokros & Alison, 2002; Woodhams, Grant *et al.*, 2007), on average, the Jaccard's coefficients for the linked crime pairs did not approach 1.0, providing further evidence that serial rapists are not perfectly consistent in their MO behavior. The Jaccard's coefficients from the linked and the

unlinked crime pairs were shown to overlap to quite a degree and it is clear from the descriptive statistics that some serial offenders are recorded as showing more consistency in their behavior across their crimes than others. This replicates what has been found with previous studies (Bennell *et al.*, 2009; Woodhams, Grant *et al.*, 2007). It also reflects what would be expected based on the literature regarding the role of sexual fantasy in serial sex offending (Gee & Belofastov, 2007; Hazelwood & Warren, 2000), and situational variation due to victim behavior, third-party disturbance or changes in offender mood (Davies, 1992; Hazelwood & Warren, 2004; Labuschagne, 2010). This suggests that in practice whilst we might be able to identify the series of some rapists based on similarity in MO behavior, there are others for whom this would be very difficult, if not impossible. This may be because the offenders are not sufficiently consistent or distinctive in their MO, or it is possible that the ways in which they express behavioral consistency are not discernable to the victim or are not routinely recorded in police files.

Within the literature on risk assessment, it has been recognised that for some offenders it will not be possible to classify them as being at high- or low-risk of violent recidivism using actuarial methods (Monahan *et al.*, 2001) because "based on current knowledge, the aggregate degree of risk presented by these intermediate cases cannot be statistically distinguished from the base rate of the sample as a whole" (p. 92). Similarly, for case linkage we might be able to confidently classify some crime pairs as linked (due to their large Jaccard's coefficients) and others as unlinked (due to their small Jaccard's coefficients). However, as suggested by the overlapping distributions reported here and by other authors (Bennell *et al.*, 2009; Woodhams, Grant *et al.*, 2007), there are also likely to be some crime pairs which we will not be able to confidently

classify as linked or unlinked. Analyses that allow for the investigation of such a scenario are underway (Bennell *et al.*, 2011).

Despite recognising some of the difficulties in classifying offenses as belonging to the same series or not, the ROC analyses produced figures indicative of adequate to excellent levels of predictive accuracy. The AUC of .77 obtained in the current study when sampling a constant number of offenses from each rape series was very similar to that obtained by Bennell *et al.* (2009), which was .75, under similar sampling conditions. That adequate levels of predictive accuracy were reached under the more stringent conditions is promising and suggests that the findings from UK and European samples generalize to South Africa. Such findings are important when one considers that linkage analysis is used to inform police investigations as well as legal proceedings in South Africa (Labuschagne, 2006, 2010).

4.3. Examination of temporal proximity and expertise

Since 2007, a handful of studies have investigated the relationship between behavioral consistency and expertise and time elapsed between offenses. When sampling all linked pairs, there was no discernable relationship between behavioral consistency and time elapsed, which replicates findings with serial juvenile sex offenders (Woodhams, *et al.*, 2008), car thieves (Tonkin *et al.*, 2008), and burglars (Markson *et al.*, 2010). However, as noted above, offenders vary in the degree of consistency they show across their series, therefore, analyses were repeated using the series containing five or more offenses to determine if such a relationship would hold for some offenders but not others. For most offenders there was a weak or moderate negative relationship between consistency and the amount of time (in days) elapsed between offenses within crime pairs, whereas for two offenders there was a weak

positive relationship or none at all. For no offenders was there a strong negative relationship, as predicted.

There are several reasons why this might be: first, in light of the under-reporting of rape to the authorities in South Africa, as in other countries (Statistics South Africa, 2000), there are likely to be gaps in series with offenses missing from the sequence. Second, as indicated by the distribution of Jaccard's coefficients for linked crime pairs, the serial offenders in this sample are not perfectly consistent in their behavior. As noted above, this can be for several reasons, not least of all victim behavior and its potential for inhibiting the expression of desired behaviors by the offender (Davies, 1992; Labuschagne, 2010).

Regarding the effect on behavioral consistency of offenders accruing experience in offending, the number of prolific offenders in the current sample precluded the use of inferential statistics; however, comparison of the Jaccard's coefficient for the first crime pair and the last crime pair in the series suggested some indication of increasing consistency with increasing experience for seven offenders. Needless to say, this is a potential relationship that would benefit from further investigation, however it is likely the relationship is complex in nature. As recently explained by Sorochinski and Salfati (2010), and as referred to above, there are several reasons why we might see behavioral change from offense-to-offense even when an offender has gained experience of offending, such as changes in violence due to frustration at being unable to achieve a fantasy.

4.4. Limitations

With regards to the limitations of the current study, the sample size (N = 22 series), whilst similar to other linkage studies (N = 23 series, Salfati & Bateman, 2005;

N = 16 series, Santtila *et al.*, 2005; *N* = 23 series, Santtila *et al.*, 2008; *N* = 19 series, Sorochinski & Salfati, 2010), is still small and thus the findings will need replication. Further, when conducting case linkage in reality, practitioners must try to identify crime series from large collections of crimes that were committed by both serial and non-serial offenders. On this occasion, the researchers were not able to collect a sample of apparent one-off rapes to include in the analyses to more closely resemble the reality of case linkage; however, future research will address this limitation.

The decision was taken to investigate the discrimination accuracy of all MO behaviors combined rather than considering the relative performance of different types of MO behaviors, as has been done in previous studies of rape (e.g., Grubin *et al.*'s (2001) analysis of control, escape, sex and style behaviors). This decision was taken because studies utilising ROC analyses have reported superior performance when testing the predictive accuracy of all MO behaviors combined compared to individual behavioral domains (Bennell *et al.*, 2009). This said, there remains the possibility that some combination of individual MO behaviors (not necessarily reflecting pre-defined domains) might be more effective for linking crimes than MO behaviors overall. This is an important avenue for future efforts.

4.5. Conclusion

It is tentatively concluded that initial evidence has been found supporting the underlying assumptions of case linkage with serial rapes from South Africa. This adds to a growing body of linkage research which, despite methodological shortcomings, is finding serial offenders to be sufficiently consistent and distinctive in their MO behavior for series to be differentiated.

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Appendix 1: Checklist of offender behaviors.

Hours of light
Weekday
Lone Victim
On Foot
Car
Bicycle
Stalked
Hides
Surprise
Con-engages
Con-employ
Con-offers help
Con-authority
Con-needs help
Con-bribe
Urinates
Extended con
Property stolen
Identifies victim
Engaging manner
Inquisitive
Impersonal
Direct threat
Indirect threat
Demeans
Verbal aggression
Lie to upset
Confrontation
Compliments
Self-disclosure
Implies knowing
Positive presentation
Sexual comments
Remorse
Mitigates responsibility
React-not deterred
Reassures
React-accommodates

Consideration
Sexual participation
Undressed victim
Penile vaginal penetration
Penile anal penetration
Digital vaginal penetration
Masturbate offender
Multiple rape
Fellatio
Kissed
Physical intimacy
Erection
Ejaculation
Erectile dysfunction
Self masturbation
Pornography
Breast
Requires victim look
Simulates intercourse
Sandwich rape
Instrumental violence
Gratuitous violence
Witness-violence
Binding
Gagging
Ripped clothes
Strangling
Slapping
Punching
Kicking/Stamping
Bludgeoning
Hair-pulling
Cutting
Shooting
Biting
Whipping
Pelting
Liquid-face

Public approach
Private approach
Public assault
Private assault
Vehicle assault
Contained
Forced entrance
Intrudes
Weapon seen
Weapon-to scene
Weapon-from scene
Knife
Firearm
Rock
Bottle
Handbag
Slingshot
Wire
Ornament
Stick
Blindfold
Disguise
Prevent look
Condom
Clean
Precautionary question
Lie - protect identity
Don’t report
False report
Stay
Pursues
Extends time
Returns victim
Further contact
Releases victim
Calm departure
Rapid departure
Gives gift

Table 1: Correlations for temporal proximity and behavioral similarity overall, and for each series of five or more offenses.

	Series Number									
	All	5	9	10	11	15	16	17	20	22
r	-.02	-.10	-.17	.24	-.30	-.18	.29	-.25	-.26	-.46
p	n.s.	n.s.	<.01	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
n	599	21	406	36	21	15	15	15	10	10

Table 2: The Jaccard's coefficient for the first and last offense pair in the eight series which had a length equal to or greater than 5 offenses (n = 9).

	Series Number								
	5	9	10	11	15	16	17	20	22
First Offense Pair	.38	.34	.48	.61	.44	.69	.50	.52	.20
Last Offense Pair	.56	.48	.65	.52	.48	.52	.61	.57	.55

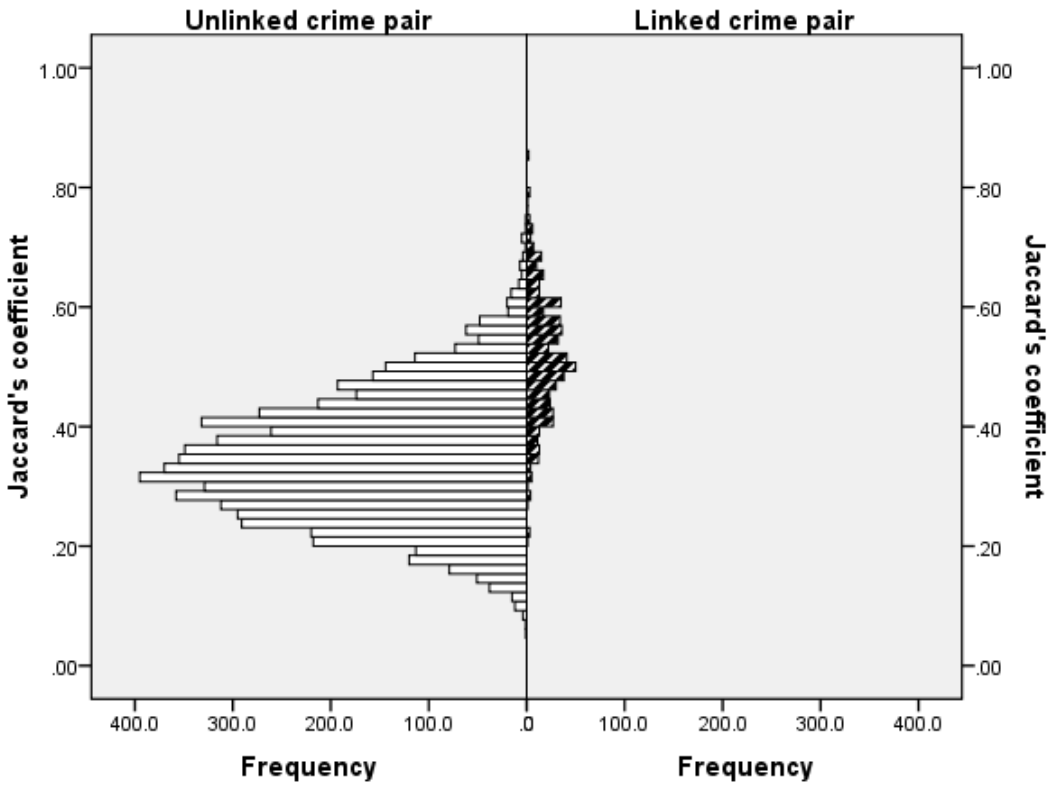

Fig. 1: The distribution of Jaccard's coefficients for unlinked crime pairs (left) and linked crime pairs (right) (N = 7021 pairs).

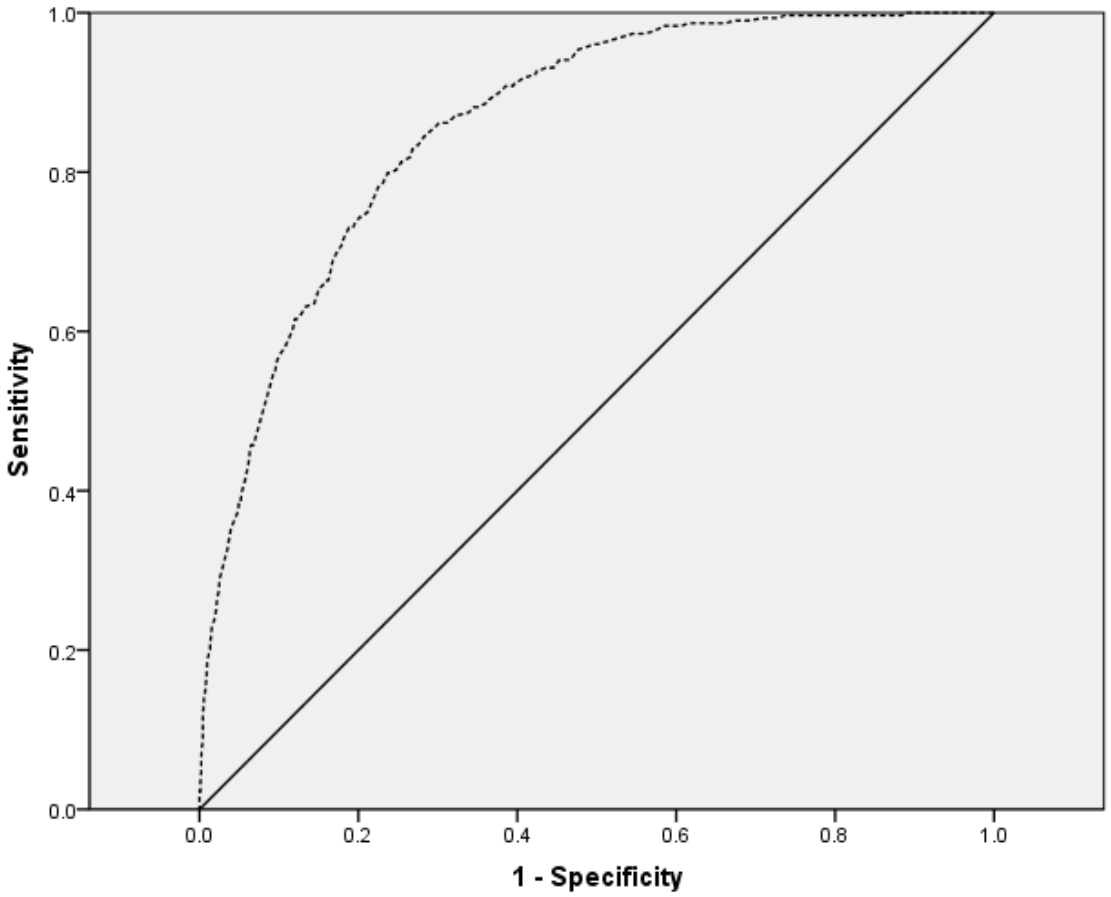

Fig. 2: The ROC graph for differentiating linked and unlinked crime pairs using MO behaviors (*N* = 7021 pairs).

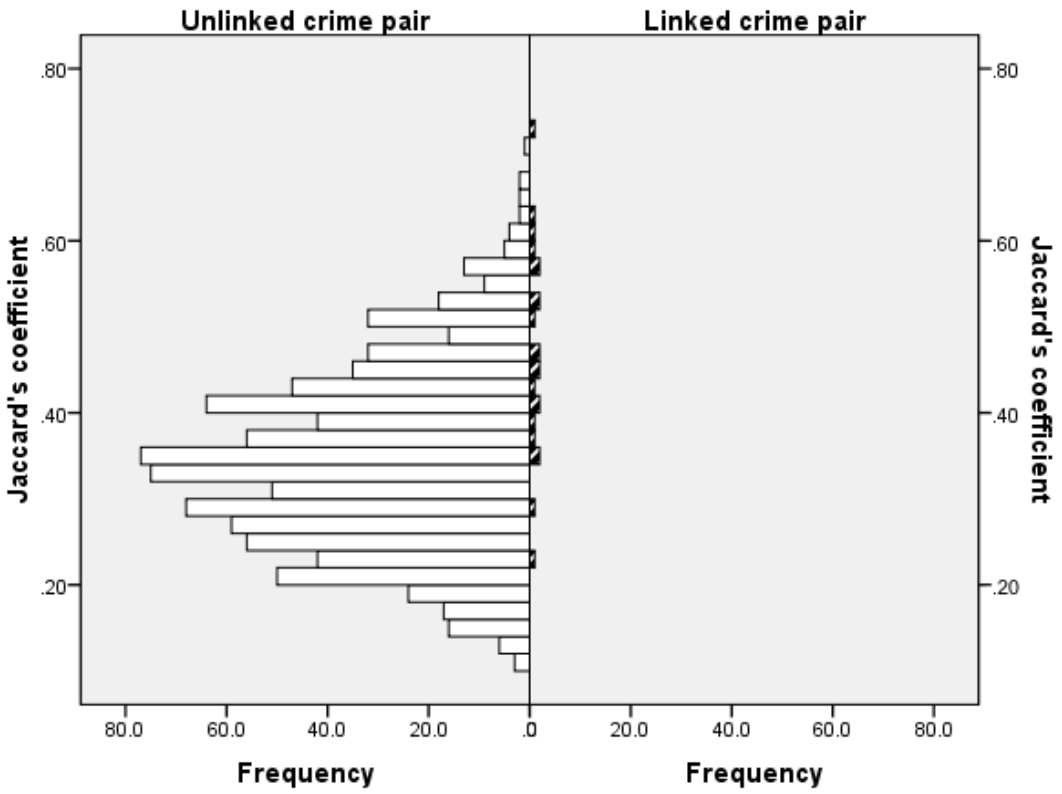

Fig. 3: The distribution of Jaccard's coefficients for unlinked crime pairs (left) and linked crime pairs (right) when sampling only two crimes from each of the 22 series (*N* = 946)

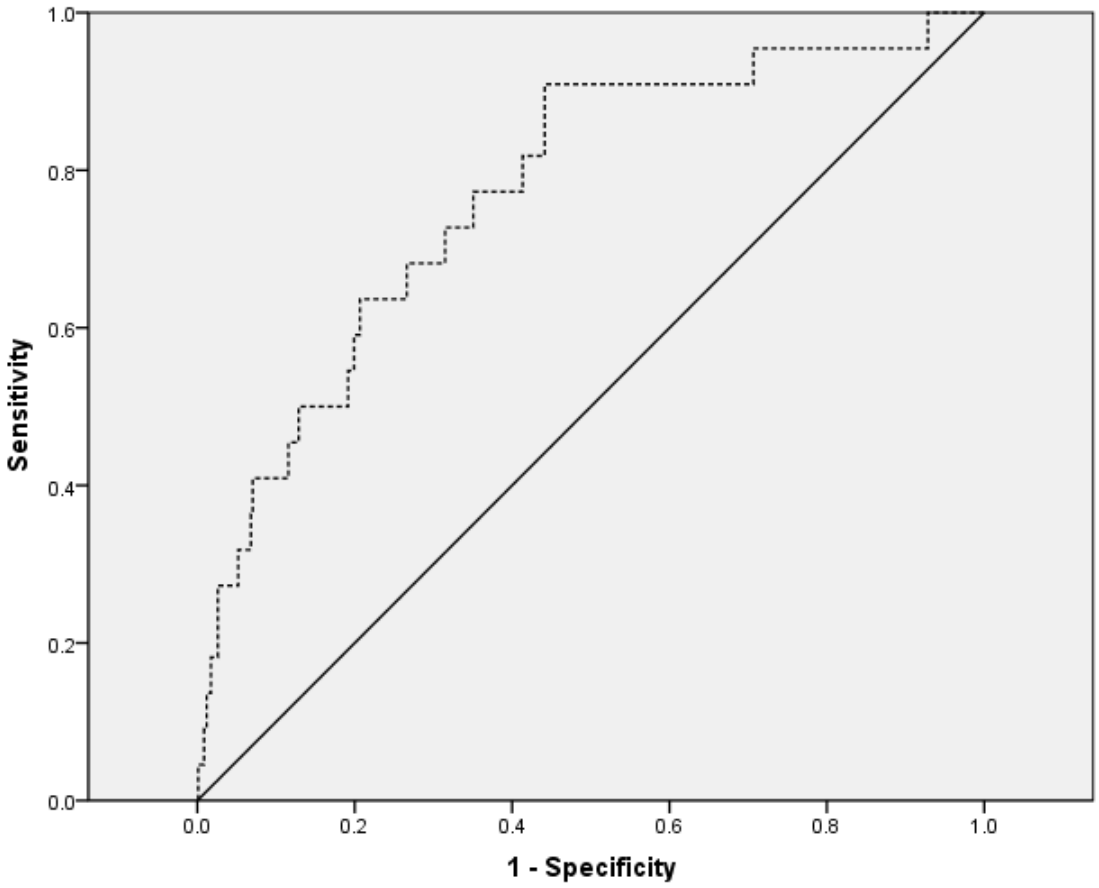

Fig. 4: The ROC graph for differentiating linked and unlinked crime pairs using MO behaviors (N = 946 pairs).

[i] A hit is where crimes are predicted to be linked and they do belong to the same series in reality, a correct rejection is where crimes are predicted to be unlinked and they are the work of different offenders in reality, a false alarm is where crimes are predicted to be linked and in reality they are the work of two different offenders, and a miss is where crimes are predicted to be unlinked whereas they do belong to the same series in reality.

[ii] The definition adopted in this study corresponds with international research programmes on various forms of serial offending (Beauregard *et al.*, 2007; Grubin *et al.*, 2001; Park *et al.*, 2008; Santtila *et al.*, 2005; Tonkin *et al.*, 2008) and the Federal Bureau of Investigation's (2008) definition for serial murder.